

10/665,322

REMARKS

Claims 18-32 are all the claims pending in the application. Claims 18-25, 27-29, 31 and 32 are rejected on prior art grounds. Claims 26 and 30 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form. Therefore, claims 26 and 30 have been rewritten in independent form. Applicants respectfully traverse these rejections based on the following discussion.

I. The 102(e) Rejection Based on Li

Claims 18-32 stand rejected under 35 U.S.C. §102(e) as being anticipated by Li (6,136,690). Li is directed to a method of de-oxidizing a surface onto which a refractory metal or molecule which contains a refractory metal atom will be adhered. The method utilizes a plasma which includes a gas such as argon, nitrogen, helium or hydrogen, or a mixture of any of the foregoing, to remove oxygen molecules from the surface to which adherence of the refractory metal is desired. Radicals in the plasma coat the surface to prevent further oxidation. The method in Li also includes techniques for depositing refractory metals onto a surface such as a substrate or layer of semiconductor material on which integrated circuitry has been fabricated.

As shown in Li, one method of increasing the adhesion between a refractory metal and underlying layers is to incorporate an intermediate material having a high degree of adhesion to both the refractory metal and the underlying materials. For example a titanium nitride liner can be used with a tungsten contact to increase adhesion. However, a titanium liner formed according to conventional processes can include excessive amounts of oxygen and silicon because the underlying silicon reacts with the fluorine during the tungsten chemical vapor deposition process. Such fluorine and oxygen compounds are very resistive and decrease the adhesive properties of the titanium liner.

More specifically, the conventional anneal forms titanium silicide moving upward through the titanium liner, and titanium nitride moving downward through the titanium liner.

10/665,322

Further, the titanium oxidizes with any free oxygen which is within the anneal furnace. The titanium silicide formation is faster than the titanium nitride formation which allows substantial amounts of silicon to penetrate through the titanium. During the subsequent tungsten chemical vapor deposition, fluorine forms both titanium fluorides and silicon fluorides in the titanium liner. The fluorine compounds degrade the conductive and adhesive properties of underlying layers. The fluorine content is especially high at the titanium liner/tungsten interface and a significant amount of this fluorine penetrates into the layers beneath the titanium underlayer. For a more detailed explanation of this problem see page 7, line 9 - page 8, line 12 of the application. The present invention overcomes these problems by doping the liner with a passivating agent to form a barrier prior to the annealing process. More specifically, the invention introduces a passivating agent plasma (e.g., nitrogen, oxygen, fluorine and chlorine) during a portion of the otherwise pure liner deposition, which allows a sub-stoichiometric barrier to be incorporated into the central portion of the liner.

The sub-stoichiometric barrier of the passivating agent helps to keep the liner from bonding with impurities during the annealing process by bonding the central portion of liner with the passivating agent instead of with the impurities. By including the passivating agent in the central portion of the liner, there is less free liner material available to bond with the impurities during the annealing process. Thus, any such impurities which bond with the liner will be principally limited to the upper portion of the liner. For example, titanium is highly reactive and will absorb oxygen (e.g., an impurity) very quickly when annealed. The fixed passivating agent barrier limits the oxidation of the upper portion of the liner (e.g., see page 9, lines 3-11 of the application).

The inventive passivating agent barrier similarly limits the amount of liner material that is available to bond with impurities (e.g., silicon), diffusing from lower layers. Thus, the barrier layer prevents, for example, silicon agglomeration during the annealing process. By reducing the amount of silicon in the liner, the formation of fluorine compounds is reduced during the subsequent fluorine based chemical vapor deposition.

To the contrary, Li discloses that the first base layer 110 is preferably titanium (Ti), the

10/665,322

second base layer 120 comprises titanium nitride (TiN), and the plug 130 is tungsten. Titanium adheres well to silicon, titanium nitride adheres well to titanium, and tungsten adheres better to titanium nitride than to either silicon or titanium. Thus, the use of a titanium nitride base layer in Li facilitates the successful deposition and longevity of the overlying tungsten layer. Therefore, Li is silent regarding any "barrier" that is "a passivating agent" and "said barrier impeding a subsequent reaction of at least a top half of said refractory metal liner with an adjacent conductive layer" as defined by independent claim 18. Similarly, Li does not teach or suggest that the barrier impedes "first impurities from diffusing from said first conductive layer through said liner" and "said barrier impedes second impurities from diffusing from said second conductive layer through said liner" as defined by independent claims 25 and 29.

Therefore, it is Applicants' position that Li does not teach or suggest the invention defined by independent claims 18, 25, and 29. Thus, Applicants submit that independent claims 18, 25, and 29 are patentable over the prior art of record. Similarly, dependent claims 19-24 are also patentable, not only because they depend from a patentable independent claim, but also because of the additional features of the invention they define. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

II. Formal Matters and Conclusion

In view of the foregoing, Applicants submit that claims 18-32, all the claims presently pending in the application, are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

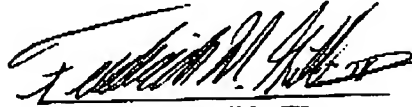
Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary.

10/665,322

Please charge any deficiencies and credit any overpayments to Attorney's Deposit
Account Number 09-0456.

Respectfully submitted,

Dated: 11/19/04



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